Mona Offshore Wind Farm
Fferm Wynt Alltraeth

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Archaeological Method Statement for Geotechnical Site Investigations 2026 to 2028

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Table of contents

Table of Acronyms

Abbreviation	Definition
AEZ	Archaeological Exclusion Zone
ADS	Archaeological Data Service
BH	Borehole
BIIS	British and Irish Ice Sheet
COARS	Coastal and Offshore Archaeological Research Services, University of Southampton
CPT	Cone Penetrating Test
DCO	Development Consent Order
DESNZ	Department for Energy, Security and Net Zero
dMLs	Deemed Marine Licences
DNA	Deoxyribonucleic Acid
ECC	Export Cable Corridor
EXC	Export Cables
FAR	Frameworks for Archaeological Research
IACs	Inter-array cables
ICCs	Interconnector cables
ISIS	Irish Sea Ice Stream
ISB	Irish Sea Basin
JNBP	JERA Nex bp
MA	Maritime Archaeology Ltd.
MBES	Multibeam Echosounder
ML	Marine Licence
MS	Method Statement
NOCS	National Oceanography Centre Southampton
NRW	Natural Resources Wales
OASIS	Online Access to the Index of Archaeological Investigations
OSPs	Offshore Substation Platforms
PAD	Protocol for Archaeological Discoveries
PSD	Particle Size Distribution
RA	Retained Archaeologist
RCAHMW	Royal Commission on the Ancient and Historical Monuments of Wales
SBP	Sub-bottom Profiler
SI	Site Investigation
SoS	Secretary of State
SSS	Side Scan Sonar
UXO	Unexploded ordnance
VC	Vibrocore
WTG	Wind Turbine Generators

Abbreviation	Definition
WIS	Western Irish Sea
WSI	Written Scheme of Investigation

List of tables

1 Introduction

1.1 Project Background

The Mona Offshore Wind Project (hereafter referred to as Mona) is being developed by Mona Offshore Wind Limited (the "Applicant"), a wholly owned company of JERA Nex bp. Mona is located in the east Irish Sea and will have a transmission capacity of up to 1.5GW at the point of connection to the grid.

The Mona Array Area is in Welsh offshore waters (beyond 12 nm from the Welsh coast). The offshore export cables and related works located within and between the Mona Array Area and the landfall will be routed through the Mona Export Cable Corridor (ECC) and Access Areas, which overlap with both Welsh offshore and Welsh inshore waters. Landfall will be made at Llanddulas, and the Mona ECC will head south before turning east at Moelfre. The Onshore Substation will be sited to the south of the St Asaph Business Park to facilitate connection to the Bodelwyddan National Grid Substation via the Mona 400 Kilovolt (kV) Grid Connection Cable Corridor.

The Project was awarded a Development Consent Order (DCO) on the 4th of July 2025 by the Secretary of State for the Department for Energy, Security and Net Zero (DESNZ). The DCO includes a Deemed Marine Licence (dML) which covers the Generation Assets (Wind Turbines Generators (WTGs), Offshore Substation Platforms (OSPs) inter-array cables (IACs) and interconnector cables (ICCs)). A separate, standalone Marine Licence (ML) covers activities within 12 nm of the Welsh coast. This was awarded on 24th September 2025 and covers works associated with the offshore export cables (EXCs), ICCs, OSPs, and landfall connection works.

The Project once fully constructed will include the following offshore elements:

- WTGs (up to 96)
- Up to four OSPs
- IACs connecting the WTGs
- ICCs connecting the OSPs

As per the methodology in the Outline Offshore Written Scheme of Investigation (WSI), this document presents an archaeological Method Statement (MS) for geotechnical Site Investigations (SI) within the Mona Array Area, ECC, and intertidal area which are proposed to be undertaken between 2026 and 2028. These works are subject to separate Marine Licences, as granted by Natural Resources Wales (NRW). Investigations will include both geotechnical and geophysical works, with geophysical investigation focusing on the areas in which sampling will occur to ensure the area of impact is clear of unexploded ordnance (UXO) and archaeological features (noting that the geophysical survey works are considered an exemptible activity and therefore are not considered within this MS). Further details on the scope are provided in Section 2. The surveys are required to better understand the seabed and shallow sub-seabed conditions and characteristics to feed into detailed engineering design.

It should be noted that a ML has been awarded for the undertaking of geotechnical works within the Mona Array Area (RML2602) between 01 April 2026 and 31 October 2028, with a variation to that licence having been submitted to NRW for consideration. Seperate ML applications are also being made for the ECC and intertidal area surveys, with this archaeological MS covering the geotechnical works under all three licences.

Several archaeological and geoarchaeological assessments of the Project area have been undertaken previously, as summarised in Section 1.2. This MS, therefore, aims to demonstrate how the geotechnical SIs will be compiled with previous SIs to provide a more holistic understanding of the geoarchaeological potential of the area.

This document has been produced by Maritime Archaeology (MA), as the Retained Archaeologist (RA) on behalf of Mona Offshore Wind Limited.

1.2 Archaeological and Geoarchaeological Background

The marine archaeological resource in the Project area is considered to comprise of:

- Prehistoric archaeology;
- Intertidal archaeology;
- Maritime archaeology; and

- Aviation archaeology.

Within the Project area there is the potential for previously undiscovered prehistoric sites and deposits of palaeoenvironmental interest, corresponding to times when sea levels were lower and hence prehistoric hominin populations may have inhabited what is now the seabed. Archaeological material may also be present within secondary contexts, such as isolated finds within reworked deposits.

Relevant archaeological reports and associated WSI documents have been undertaken for the Project as summarised in Table 1.

Table 1 Relevant archaeological reports completed to date

Archaeological report	Year	Report summary
Mona Offshore Wind Project Environmental Statement Volume 6, Annex 9.1: Marine Archaeology Technical Report MOCNS-J3303-RPS-10087	2024	Encompasses desk-based assessment utilising information from existing heritage datasets across the development area.
Mona Offshore Wind Project Environmental Statement Volume 2, Chapter 9: Marine Archaeology (F02) MOCNS-J3303-RPS-10047	2025	Summarises the existing baseline conditions for the marine archaeological and cultural heritage within the offshore development area and sets out the impact assessment.
Mona Offshore Wind Project Outline Offshore Written Scheme of Investigation and Protocol for Archaeological Discoveries (B03) MOCNS-J3303-RPS-10155	2025	Sets out the proposed approach to archaeological mitigation and investigations to be undertaken.
Mona and Morgan Offshore Wind Farms Stage 1 (2022) Geoarchaeological Assessment MMCNS-J4022-COARS-50001	2023 Submitted to and approved by RCAHMW in August 2025	Staged geoarchaeological assessment of boreholes and vibrocores collected in 2022.
Mona Offshore Wind Project Stage 2 Geoarchaeological Assessment	In progress	Staged geoarchaeological assessment of boreholes and vibrocores collected in 2022, 2023, 2024, 2025.
Mona Offshore Wind Project Stage 1 (2023 – 2025) Geoarchaeological Assessment MOCNS-J1206-COARS-50001	2026 Submitted to and approved by RCHAMW in April 2026	Staged geoarchaeological assessment of borehole and vibrocores collected in 2023-2025.

1.2.1 2021-2022 Site Investigations

Geophysical surveys of the Mona Array Area were undertaken by Gardline between 09 July 2021 and 08 September 2021, and XOcean between 12 June 2021 and 16 March 2022. Full coverage was achieved and Side Scan Sonar (SSS), Multibeam Echosounder (MBES) and Sub-bottom Profiler (SBP) data was collected (RPS, 2024). Geophysical surveys of the Mona ECC were undertaken by Gardline between 01 April 2022 and 10 July 2022, by Titan between 07 June 2022 and 15 August 2022, and XOcean between 25 April 2022 and 19 September 2022. Near-full coverage was achieved and SSS, MBES, SBP and magnetometer data was collected (RPS, 2024). The SBP data assessment informed both the initial Project geological ground model (outlined in Table 2) and the geotechnical survey phase (COARS, 2023).

A geotechnical campaign was carried out within the Mona Array Area and ECC in 2022 and comprised of both deep geotechnical SIs (up to 70m below the seabed) and shallow geotechnical SIs. The coring targeted several

seabed and sub-seabed features that were identified during the geophysical campaign undertaken from 2021 to 2022.

The deep geotechnical SIs were undertaken by Fugro Marine Limited (Fugro) aboard the MV *Normand Mermaid* from 19 June to 23 July 2022, and the MV *Fugro Synergy* from 10 June to 07 October 2022, with a total of 24 boreholes (BHs) collected within the Mona Array Area (Fugro, 2022).

The shallow geotechnical SIs were undertaken along the ECC by Gardline aboard the MV *Ocean Observer* from 27 April to 10 July 2022, and *Forth Jouster* from 29 August to 04 September 2022, with a total of 38 vibrocores taken within the Mona Array Area and ECC.

The Stage 1 geoarchaeological assessment of both the BHs and VCs was undertaken by Coastal and Offshore Archaeological Research Services (COARS). The assessment concluded that none of the VCs had any geoarchaeological potential, however; a series of proglacial, possibly lacustrine / fluvial deposits were identified in the BHs as being of geoarchaeological potential (COARS, 2023). Stage 2 recommendations focused on these proglacial deposits, with three BHs from Mona selected, as they have the potential to provide palaeoenvironmental information that can help improve the classification of glacial and/ or palaeolandscape features and provide additional refinement to the evolving Project geological ground model. Furthermore, they offer the potential for scientific dating (see Grant and Marshall 2025), and could, therefore, improve the chronological understanding of both later Devensian glacial activity, and the presence of a submerged palaeolandscape within the region (COARS, 2023).

The interpretation of the site ground model (Wood and Deeks 2022) showed thick deposits of Holocene marine sands and gravels (Unit I), increasing in thickness towards the Welsh coastline, and locally up to 12m in thick. These overlie the Unit II WIS-A towards the north of the ECC, within the funnel area, but appear to be absent south of 5920000 N (UTM 30N). Underlying all these deposits are the Unit VII Cardigan Bay Formation, except for at the proposed landfall where Mercia Mudstone Group is present. This matches the sequence of deposits identified within the VCs, consisting of sands and gravels associated with Unit I and soft clays from Unit II. All these deposits are interpreted as being marine in origin and therefore unrelated to any submerged palaeolandscape features of geoarchaeological interest (COARS, 2023).

Units VI and V are sub-divided geotechnically into three and five sub-units respectively. Within Unit V, the sub-units are not always easily distinguishable from each other in the seismic data, but within Unit VI, Units VIa and VIb can be distinguished. Unit VIa is characterised by sub-parallel weak bedding, while Unit VIb is generally more chaotic and structureless. Unit VI consists of a prominent deep channel / tunnel valley bisecting the centre of Mona in a northeast to southwest trend, with several stages of cut and fill, whereas Unit V has formed in a shallow basin with shallow flanks and weakly bedded internal reflections. The main distinguishing feature of Unit V is the nature of the basal reflection, which is serrated (sawtooth like) and typical of glacial deposits that have either been affected by ice sheet plough marks or seasonal outwash currents (Wood and Deeks 2022). Units V and VI are both classified as probable glacial lakes within the depositional facies stratigraphic framework (COARS, 2023).

1.2.2 2023-2025 Site Investigations

Deep geotechnical site investigations (up to 70m below the seabed) were undertaken by Fugro aboard the MV Fugro Synergy, from the 16 June to 16 November 2023 (Fugro, 2024a), from the 13 June to 9 August 2024 and from the 5 September to 16 October 2024 (Fugro, 2024b), and from the 3 June to 23 September 2025 (Fugro, 2025). These on-site investigations resulted in the collection of 134 BHs (COARS, 2026).

The Stage 1 geoarchaeological assessment of the BHs was undertaken by COARS. Within the Mona Array Area, each of the ground model stratigraphic units was assessed, focusing on Units IV, V, VI which may hold the greatest geoarchaeological potential. A range of geotechnical measurements conducted upon the recovered boreholes have been considered for Units VI and V. Borehole datasets used include particle size distribution (PSD), Atterberg limits and water content (COARS, 2026).

Units VI and V are sub-divided geotechnically into six and three sub-units respectively. This is an increase in the number of subunits identified within the original ground model (Wood and Deeks 2022)(COARS, 2023) which has been achieved as a result of increased seismic data coverage and refinement of the ground model in light of the additional geotechnical site investigations undertaken within the Mona Array Area (COARS, 2026).

Unit VI consists of a prominent deep channel/tunnel valley bisecting the centre of Mona Array Area in a northeast to southwest trend, with several stages of cut and fill. Unit VIe can be identified within the boreholes by the presence of a distinctive thick deposit of weakly bedded grey clay that is most likely attributed to plumite

– a sediment deposit formed from meltwater plumes that occur underneath or at the edge of glaciers, particularly during periods of intense ice sheet retreat. Unit VId was only encountered within one borehole from within Mona Array Area and can be attributed to pro-glaciofluvial deposition, with the seismics showing that some of this Unit was also locally glacio-tectonized, associated with ice-push moraines. Unit VIc also showed signs of being locally tectonized and associated with ice-push ridges but are more likely to be associated with a glaciofluvial origin. Units VIa and VIb are both attributed to glaciolacustrine deposition and can be distinguished within the seismic data (COARS, 2026).

Within the northern part of Mona Array Area, a till was visible towards the top of Unit VI. This till represents a previous unknown glacial resurgence over the northern edge of the Mona Array Area, likely leading to some of the glacitectonic deformation observed within the underlying Unit VIa/b deposits. Unit V, deposited following the retreat of the Unit VI glacial resurgence, formed in a shallow basin with shallow flanks and weakly bedded internal reflections. The main distinguishing feature of Unit V is the nature of the basal reflection, which is serrated (sawtooth like) and typical of glacial deposits that have either been affected by ice sheet plough marks or seasonal outwash currents (Wood and Deeks 2022)(COARS, 2026).

Unit Vc consists of medium dense to very dense sand attributed to glaciofluvial or glaciolacustrine deposition, likely as a deltaic outwash fan. Units Vb and Va are like those associated with Units VIb and VIa, also attributed to glaciolacustrine deposition. These silty clays often lack the clear laminations that were present within the Unit VIb deposits, though occasional silt laminae are noted. However, X-rays of cores do show that gravel inclusions, when platy, are often orientated horizontally or sub-horizontally, sometimes locally deforming weak laminations, implying settling of dropstones within a glaciolacustrine or glaciomarine setting (COARS, 2026).

VI Till is likely to be a glacial till, whereas VIa and especially Vb might be a weathered derivative of tills, which could have been eroded and redeposited in a glaciomarine or glaciolacustrine setting. Weathered till tends to have a higher water content, lower density and a greater plasticity, the latter also demonstrated by the position of these units relative to each other within the Casagrande plots. If the Unit V and VI deposits relate to a glacial lake and were deposited within a glaciolacustrine or glaciomarine setting, then the presence of sedimentary structures, such as laminae and dropstones, along with variations in particle size distribution, support this interpretation (COARS, 2026).

The presence of laminae within some of the Unit VI and V deposits indicates a complex range of depositional environments during this period support the presence of a water body being present within this are, possibly a glacial lake as proposed by Wood and Deeks (2022). Suitable deposits have been sampled that would permit the testing of this theory, as well as material that may be suitable for geochronological techniques, either through radiocarbon dating of shell material or luminescence dating of the fine sand to silt fraction deposits which are prevalent in these deposits (COARS, 2026).

If the taphonomy of these samples is deemed to be suitable for the chosen dating technique, establishing their age could provide valuable new insights into the Late Devensian dynamics of the ISIS and palaeogeography of the area, including the timing of the Unit VI Till and glacial readvance, as well as constraining the age of the underlying Unit VII tills. Palaeoenvironmental assessment (e.g. diatoms or foraminifera) from some of these deposits could also assist with determining the depositional environment (glaciolacustrine vs glaciomarine). Stage 2 recording of some of these sediments would be required to determine this (COARS, 2026).

Unit IV comprises of eight sub-units (though Unit IVde is absent in Mona), all of which are interpreted to represent the retreat of the ISIS at the end of last glacial period. These deposits are equivalent to the Western Irish Sea (WIS) Formation A Chaotic Facies. Unit IV is closely linked to the rugose seabed and prevalence of glacial morphological features (Wood and Deeks 2022).

Within the Mona Array Area, clear separation of a variety of channel sizes and geometries can be observed. The lower channel sequence is generally straight, broad, and flat-based, associated with dense sands, while the upper channel sequences are V-shaped, narrower and consist of braided channels. Also present are units of very coarse gravel and cobbles, indicating a high-energy environment, possibly even a glacial lake outburst, and outwash fans (also see Chiverrell and Van Landeghem 2013)(COARS, 2026).

Unit IVg represents a complex channel with multiple-phase fills associated with a deeply cut channel, at least 10km in length, aligned northeast to southwest. This unit was not sampled during the 2023-2025 campaigns but was sampled in 2022, with borehole MON-BH22-11 already selected for Stage 2 geoarchaeological assessment (COARS, 2023)(COARS, 2026).

Units IVf and IVe are both attributed to glaciofluvial deposition within an ice-marginal fan. These typically consist of dense to very dense sands. An X-ray of core MO-056-BH-005b shows the presence of cross-bedded

sands, likely formed by the action of fast-flowing meltwater streams issuing from retreating glaciers (COARS, 2026).

Unit IVd is a complex and highly variable unit that is widespread across the Outwash Plain Domain, sitting above a ravinement surface. These ravinement surfaces are present on the western side of the Mona Array Area and can be laterally traced into Celtic Array to the west. Some rotational fault blocks associated with the ravinement surfaces were also present, which were provisionally interpreted as possible low lying shoreline cliffs (G. Wood pers. comms.). These ravinement surfaces may therefore relate to a marine planar surface representing erosion during post-glacial marine transgression (COARS, 2026).

Unit IVc is typified within the seismic data as a form of sigmoidal delta-like structures, which appear to have prograded from the northwest. Units IVa and b represent glaciofluvial channelling, likely part of an outwash channel. Fine grained sediments present within several boreholes attributed to the Unit IV channel and fan deposits are present. These have grain sizes that are likely to be suitable for luminescence dating, though the unconsolidated nature of some of these sands meant that they were subject to light exposure when the cores were split open, rendering them no longer suitable for dating. However, several cores have associated save tubes from the relevant Unit IV deposits, so these should provide suitable alternative samples for luminescence dating, if required. In addition, shell material noted within the Unit IVd deposits, overlying the ravinement surface, which may provide material suitable for radiocarbon dating to help constrain the age of marine transgression within the local area (COARS, 2026).

Within the Mona Array Area, a series of proglacial, possibly lacustrine / fluvial deposits, have been identified within several of the Units identified within the ground model. These offer the potential to be dated and therefore improve the chronology of the timing of Devensian glacial advance and retreat, and presence of a submerged palaeolandscape, within the region. These are also likely to provide palaeoenvironmental information that can help improve the classification of these features and provide additional refinement to the evolving ground models (COARS, 2026).

The presence of two distinctive ravinement surfaces aligned broadly north-south through the western side of the Mona Array area attest to the post-glacial marine transgression in the area, with material from the sands directly overlying these surfaces offering potential to either constrain the age of these surfaces or potentially contain a record of coastal deposition (COARS, 2026).

Following the review of the borehole records from the 2023-2025 geotechnical investigations, recommendations are made to further investigate some of the borehole sequences. These recommendations are made in conjunction with previous recommendations made for the geoarchaeological assessment of material collected during the 2022 geotechnical investigations (COARS, 2023). Samples identified from 11 boreholes collected between 2023 and 2025 and suitable for Stage 2 recording (COARS, 2026).

1.2.3 Geological ground model

Table 2 Geological ground model for Mona Array Area and ECC (Wood and Deeks, 2022; updated 2026)

Stratigraphy		Unit	Depositional Facies	Lithology
Formation	Member			
	Mobile Sands	Unit I	Marine	Loose to dense gravelly sand
WIS-A	Mudbelt	Unit II	Glaciomarine	Very low to low strength clay
	Prograded Sands	Unit III	Glaciomarine, pro-deltaic	Dense to very dense sand and gravel
	Chaotic	Unit IVa	Glacio-fluvial; Outwash Plain (sandur); Outwash Phase 3 Channels (distal). Also includes deposits over ravinement surfaces	Dense to very dense sand with gravel

Stratigraphy		Unit	Depositional Facies	Lithology
Formation	Member			
		Unit IVb	Glacio-fluvial; Outwash Plain sandur); Outwash Phase 2 Channels (proximal)	Dense to very dense sand and clay
		Unit IVc	Glacio-marginal; Grounding Zone Fan / Ice-contact delta	Gravel and dense to very dense sand and clay
		Unit IVd	Glacio-fluvial; Outwash Plain (sandur); Sheet sands and gravels; Outwash Phase 1	Gravel and dense to very dense sand and gravel
		Unit IVe	Glacio-fluvial; Ice marginal fans	Dense to very dense sand
		Unit IVf	Glacio-fluvial; Ice marginal fans	Dense to very dense sand
		Unit IVg	Complex channel with multiple-phase fills	High to ultra-high strength gravelly sandy clay
		Unit Va	Glacio-lacustrine; Upper glacial lakes	Low to high strength sandy clay
		Unit Vb	Glacio-lacustrine; Upper glacial lakes (crevasse-squeeze ridges at the base; top of glaciotectonized strata)	Low to high strength clay
		Unit Vc	Glacio-fluvial to glacio-lacustrine (deltaic; outwash fans)	Medium dense to very dense sand
		Unit VI Till	Subglacial till	Glacigenic diamicton; unsorted
		Unit VIa	Glacio-lacustrine; Lower glacial lakes	Low to high strength sandy clay
		Unit VIb	Glacio-lacustrine; Lower glacial lakes. Can be laminated and / or glaciotectonized	High to very high strength clay
		Unit VIc	Glacio-fluvial (locally tectonized); ice-push ridges	Dense to very dense sand
		Unit VId	Glacio-fluvial or glacio-marginal; locally glacio-tectonized with ice-	Sand and gravel

Stratigraphy		Unit	Depositional Facies	Lithology
Formation	Member			
			push moraines (moraines and thrust stacks)	
		Unit VIId	Glaciofluvial; Subglacial meltwater channel (usually deposited above VIIal seldom within VI); generic unit capturing all eskers of all ages	Gravel and sand
Cardigan Bay	Upper Till	Unit VIIa	Sub-glacial till	Extremely to ultra-high gravelly clay, with beds of sand
	Infill Member	Unit VIII	Sub-glacial Tunnel Valley / Pro-Glacial Channel	Dense to very dense sand

The ground model indicates a series of glacial and post-glacial deposits are present. Deposits of potential significance may include the Unit V and VI postulated glacial lakes, as well as the Unit IV palaeochannels. These sequences have the potential to be associated with terrestrial palaeolandscape features, which might have supported human activity. These sequences could also provide a greater understanding of the Late Devensian palaeogeography of the area, in particular the timing and dynamics of the Irish Sea Ice Stream (ISIS) within the Irish Sea Basin (ISB) (COARS, 2026).

Further to the above, data and results from previous and current scientific projects and research frameworks within the Irish Sea, outlined in Table 3 below, will be utilised to add to current understanding where relevant.

Table 3 Previous and ongoing research projects focusing on the Irish Sea

Project title	Status, year	Project summary
Geological appraisal of swath bathymetry and seismo-stratigraphic data in the South East region of the Round 3 zone - Liverpool Bay (Chiverrell, and Van Landeghem 2013)	2013	This study presented full chronological information outlining advance and retreat of the British and Irish Ice Sheet (BIIS).
West Coast Palaeolandscapes Survey (Fitch and Gaffney 2011)	2011	The west coast of Britain was identified as an area where information on existing palaeolandscapes would have a significant impact on the understanding of the Mesolithic and, potentially, the Palaeolithic period in England and Wales. This was achieved using geophysical data to map ancient landforms like floodplains, lakes, and river channels. Some of these features were inferred to be from the Mesolithic period, and therefore could be associated with human activity, though this is all inferred as there was no independent scientific dating of any of the identified submerged palaeolandscape features. Subsequent work has now

Project title	Status, year	Project summary
		shown that many of these features are pre-Mesolithic.
BGS Review of the geology of the seabed and shallow subsurface: The Irish Sea (Mellet et al. 2015)	2015	This BGS review provides a review and synthesis of best-available geophysical and geotechnical data in the northern sector of the Irish Sea. The report outlines the current state of understanding of geological conditions at the seabed and in the shallow subsurface to depths of 50 m.
"Europe's Lost Frontiers" Research	2015-2021	Europe's Lost Frontiers research involved Irish institutions who collaborated with the main project to explore the submerged landscapes of the Irish Sea between Ireland and Britain. This was a component of the larger, EU-funded project to study prehistoric, inundated lands and was an extension of the primary research on the North Sea.
CV17040 Irish Sea Palaeolandscape Investigation Survey	2017-2025	The Irish Sea Palaeolandscape Investigation Survey will reconstruct and simulate the palaeo-environments of the Irish Sea using ancient DNA extracted directly from sediment cores and explore the palaeolandscapes of Ireland and identify incipient signals indicating early contact and development. This survey, led by IT Sligo on board the Marine Institute's Celtic Voyager, took place in November 2017 in the Irish Sea. The survey objectives were: Obtain 16 Cores from Liverpool Bay Obtain 4 Cores from Cardigan Bay; and obtain high-precision geophysical data at each of the 21 Core locations However, not all objectives were achieved as no vibrocoring took place due to bad weather conditions. The main purpose of the survey was to reconstruct and simulate the palaeo-environments of the Irish Sea using ancient DNA extracted directly from the sediment cores.

2 Scope of Works

2.1 Geotechnical Site Investigation

Geotechnical SIs are required within the Array Area, ECC, and intertidal area. The surveys will comprise of offshore collection and onshore analysis of geotechnical samples/data acquired from nominated locations. The surveys will allow for both the ground truthing of the previously collected geophysical data and better characterisation of the seabed and shallow sub-seabed conditions. The surveys will inform the cable routing, design and installation phases of the work (JNBP and EnBW, 2025a).

The scope of the geotechnical investigation includes, but is not limited to, VCs, BHs, Cone Penetration Tests (CPTs), thermal resistivity testing (*in situ* at selected locations), Pore Pressure Dissipation Testing (PPDT), High-Pressure Dilatometer (HPD) testing, borehole geological logging, and geotechnical laboratory works (JNBP and EnBW, 2025a).

BHs and VCs can produce sleeved sediment cores which have been mechanically driven into the seabed and collect a representative column of the sediments through which they pass. For archaeology, VCs and BHs allow the direct observation of minimally disturbed stratigraphy, the recovery of sediment samples for analysis, the ground truthing of geophysical data and the potential to map and model palaeolandscapes. CPT involves an instrumented cone being pushed into the sediment to measure cone-tip resistance, friction against the cylindrical shaft and excess pore water pressure generated at penetration. CPT does not produce a sediment sample useful to archaeology, but measures variations in sediment shear strength and compressibility, and is able to discriminate boundaries or changes in sediment units which can be used for geoarchaeological prospection and ground model calibration (COWRIE, 2011).

The surveys will be undertaken within the Mona Array Area, ECC and Intertidal Area between 2026 and 2028. Within the Array Area, up to 140 borehole samples and up to 500 shallow soil samples will be taken. Up to 250 shallow soil samples will be taken within the ECC, as detailed in Table 4. CPTs will be undertaken within the ECC and Array Area, utilising a minimum of three cone types, with cross-sectional areas of 5 cm², 10 cm² and 15 cm², respectively. Within the Intertidal Area, up to 10 borehole samples and CPTS will be undertaken. The CPTs will utilise a minimum of three cone types, with cross-sectional areas of 5 cm², 10 cm² and 15 cm², respectively. The exact locations of the geotechnical investigations are not yet determined but are planned to inform site design, as stated in the Aims below.

The collected material will be subject to archaeological assessment as per the methodology in Section 4 and the results will feed into the staged reports. It should be highlighted that the geoarchaeological assessment of geotechnical data will utilise all the information previously gathered from Project-specific geotechnical SIs and other projects within the region, the latter of which are highlighted in Section 4.

Table 4 Proposed number of geotechnical locations

Section	No. of Samples	Diameter (mm)	Maximum Depth (m)
Mona Array Area	Up to 140 boreholes	Instrument: 230 Sample: 102	90
	Up to 500 shallow soil samples	Instrument: 230 Sample: 102	8
Mona ECC	Up to 250 shallow soil samples	Instrument: 230 Sample: 102	8
Mona Intertidal Area	Up to 10 boreholes	Instrument : 230 Sample: 102	25

Geophysical data will be used to verify any proposed geotechnical sample location being clear of potential UXO (JNBP and EnBW, 2025b). Previously identified archaeology will be avoided by sampling locations as outlined in the Outline Offshore WSI. Should any new anomalies be identified by the onboard geotechnical contractors at a sample location, the Project specific Protocol for Archaeological Discoveries (PAD) (RPS, 2025b) will be followed and MA as the RA will be contacted. Depending on the findings, they will be assigned an

Archaeological Exclusion Zone (AEZ) suitable to the extent of the feature as a basic form of mitigation by the MA as the RA.

3 Aims and Objectives

The main aim of the geotechnical SI is to better understand the composition of the seabed and sub-seabed within the Project area to inform the engineering programme. Data collected will continue to contribute to the overarching geoarchaeological strategy of developing a collective understanding of the prehistoric environment of the Project site and the wider Irish sea.

The objectives of the geoarchaeological assessment of the geotechnical SI are to:

- Analyse newly collected cores and utilise our existing knowledge to improve the understanding of the submerged palaeolandscapes as well as the archaeological and palaeoenvironmental potential in the Project area;
- Aid in potentially addressing knowledge gaps and increase geoarchaeological data relevant and available for assessment;
- Inform mitigation strategies based on the potential impact of the Project on the historic environment.

The aims and objectives will be achieved following the staged approach set out in Section 4.

3.1 Project Specific Research Questions

COARS (2023) identified that none of the VCs that were collected along the Mona ECC in 2022 were identified as having any geoarchaeological potential. Within the Mona Array Area, a series of proglacial, possibly lacustrine / fluvial deposits, have been identified within several of the Units identified within the geological ground model. These offer the potential to be dated and therefore improve the chronology of the timing of Devensian glacial dynamics, the type and distribution of submerged palaeolandscape features present, within the region. Palaeoenvironmental information can also be used to improve the classification of these features and provide additional refinement to the evolving ground models.

Three BHs from the Mona Array Area have been identified to contain the potential to address the following questions (COARS, 2023)(COARS, 2026):

1. Did the Unit VI and V laminated deposits settle within a glaciolacustrine or glaciomarine environment, and could they confirm the presence of a large glacial lake?
2. Can dating of the Unit VI and V deposits provide an age constraint on the timing of the glacial readvance associated with the Unit VI till?
3. What is the timing of the Unit IV sandur deposits, and can they provide a constraint on glacial retreat, channel activity and subsequent marine transgression in the area?

The research questions above tie in with the Framework for Archaeological Research (FAR) (see Table 5) in establishing the current state and nature of archaeological research activity and infrastructure across Wales as well as supporting the articulation of future research questions and associated infrastructural dependencies. These include:

- A Research Framework for the Archaeology of Wales
  - Maritime - Theme 1: Climate Change and Coastal Change
  - Palaeoenvironment - Theme 2: Environmental Context and Landscape Change; Theme 7: Climate Change; and Theme 9: Coastal Alluviation and Sea-level Change
  - Palaeolithic and Mesolithic - Research Question B: Natural Landscapes; and G: Chronology

Table 5 Relevant Frameworks for Archaeological Research relevant the Project

Framework Name	Status, year	Framework Summary
A Research Framework for the Archaeology of Wales	2001-present	The Research Framework for the Archaeology of Wales is a periodically updated, collaborative initiative designed to set strategic research priorities, guide funding, and maximize the impact of archaeological investigations across Wales. It spans all periods from the Paleolithic to modern times, organized by themes focusing on landscape, maritime, palaeoenvironmental and climate adaptation.

The research questions can be answered by ensuring that sub-sampling for geoarchaeological purposes is targeted on the core material collected in areas of specific interest while also utilising previously collected cores and results from the Project area.

4 Geoarchaeological Methodology

Under this MS the following methodologies will be undertaken to help meet the objectives detailed in Section 3:

- Geoarchaeology training session;
- Archaeological analysis; and
- Archaeological assessment report.

4.1 Geoarchaeology Training Session

Prior to the commencement of the surveys, MA (the RA) will provide the geotechnical contractors with an archaeological training session drawing on information contained within this MS and the PAD.

This approach has been successfully employed by MA on several projects as well as on previous geotechnical SIs on this Project and has shown that personnel who have completed the training session are more likely to report finds or deposits of archaeological potential early in the programme. It has also shown that information contained within the BH/VC logs produced after the training session are suitable for archaeological interpretation.

The training session will be delivered by a qualified geoarchaeologist and aims to ensure that data captured during the surveys for geoarchaeological assessment and analysis is fully documented.

The overarching purpose of the training provided is to enable geotechnical staff working offshore and onshore to operate without the presence of an archaeologist, while obtaining basic records to appropriate archaeological standards.

The training session will be delivered to onboard client representatives and all relevant staff by a qualified archaeologist in person, where possible. Alternatively, it will be delivered via a live video call or pre-recorded video presentation that can be shown to further relevant personnel onboard at a later stage.

Both the live presentation and the video presentation will cover the following issues and elements:

- Introduction;
- How geotechnical survey is relevant to archaeological investigation;
- Broad background to prehistoric archaeology in offshore contexts, including areas and sites as well as find spots from submerged contexts;
- Sediment types: which are typically of interest archaeologically that they may encounter;
- Overview of the archaeological assessment sequence;
- Key issues; correct handling procedures for Scientific Dating; storing of samples; access to samples; co-operation with other users of samples; collection of archaeology-only sample(s);
- Recording and documentation procedures, including logging, coding and storage of samples in accordance with the documents and guidelines;
- Information on the procedure to be followed in the event of unexpected archaeological discoveries using the project specific PAD (RPS, 2025b);
- Summary & Conclusion; and
- Question & Answer Session (only following the live presentation).

The geotechnical contractors will be contacted periodically to ensure that the training steps are being effectively followed, and the geoarchaeologist will have direct communication with the laboratory to ensure that the material is retained in a way suitable for geoarchaeological analysis.

The work enabled by this training will constitute Stage 1 of the assessment cycle (Section 4.2.1) leading on to selective recording of BHs/VCs exhibiting evidence of archaeological potential (Stage 2).

4.2 Geoarchaeological Assessment

The geoarchaeological assessment of the geotechnical data is one part of the mitigation strategy in place to avoid and offset significant impacts on any archaeological receptors from the geotechnical SIs as well as generate geoarchaeological data in support of the palaeogeographic interpretation.

The geoarchaeologist will have direct communication with the laboratory to ensure that the material is retained in a way suitable for geoarchaeological analysis. This has been successfully employed on previous geotechnical SIs undertaken for this Project.

Geotechnical material can help with the characterisation of the seabed geology and morphology as demonstrated by Historic England (2015). This information can contribute towards the understanding of the geomorphological evolution of a landscape prior to and during marine inundation. This in turn can help focus attention on areas with the highest archaeological potential. This is achieved through the identification and analysis of geotechnical samples using the following proxy techniques:

- Microfossils such as pollen foraminifera, ostracods and diatoms which can provide data on local vegetation, salinity, coastal proximity and sea-level rise, as well as prevailing climatic conditions.
- Macrofossils such as insect, molluscs and waterlogged plant remains including seeds and wood, which can provide information on local vegetation and prevailing climatic conditions; and
- The collection of material suitable for scientific dating establish the age of the sampled deposits.

The geoarchaeological assessment of geotechnical cores follows a staged approach and has been informed by the following main articles of guidance: *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector* (COWRIE, 2011), *Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling to Post-excavation* (English Heritage, 2011), *Geoarchaeology: Using Earth Sciences to Understand the Archaeological Record* (Historic England, 2015), *Archaeological Written Schemes of Investigation for Offshore Wind Farms* (The Crown Estate, 2021), *Radiocarbon Dating and Chronological Modelling: Guidelines and Best Practice* (Bayliss and Marshall, 2022) and *Scientific Dating of Pleistocene Sites: Guidelines for Best Practice* (Grant and Marshall (eds), 2025).

The approach is composed of the following elements:

- **Stage 1 - Geoarchaeological review of core logs**: consists of a desk-based assessment of geotechnical core logs by an experienced geoarchaeologist to determine which cores contain sediments of archaeological interest. These core logs will be compared against available SBP datasets to contextualise the records and establish which cores can best inform the evolving deposit/ ground model. Recommendations will be made to the Project as to which cores the geoarchaeologist would like to look at in Stage 2 - For Stage 1 to be undertaken the core logs must be recorded in a manner which will allow identification of sediments of archaeological interest. The luminescence dating potential of the sediments is also assessed.

- **Stage 2 - Geoarchaeological recording**: a detailed inspection and recording of the cores identified in Stage 1 to further assess archaeological potential. This requires physical access by the geoarchaeologist, who will make a record of the sediments encountered and their [geo]archaeological potential. The results of the Stage 2 assessment will be used to enhance/ refine the existing ground model, with recommendations for any Stage 3 assessment made, if required.

- **Stage 3 - Geoarchaeological assessment**: samples are taken from the cores recommended (and recorded) in Stage 2 for specialist assessment to determine the age and palaeoenvironmental potential of the sediments. This stage comprises the sampling and laboratory analysis of a selected core, or cores, to a level sufficient to enable an assessment of the value of the palaeoenvironmental material (e.g. pollen, diatoms, ostracods and foraminifera) surviving within the core(s). A provision for the scientific dating of core samples (e.g. radiocarbon or luminescence dating) should be included within this stage. The assessment seeks to establish the preservation, diversity, and quantity of palaeoenvironmental material, in order to further refine the interpretation of the sedimentary environment, and past human activity, identified in the Stage 2 recording. The results of the Stage 3 assessment will be used to enhance/ refine the deposit/ ground model. Recommendations are made as to whether a Stage 4 analysis programme, including any additional scientific dating, should take place on any of the core material.

- **Stage 4 - Geoarchaeological analysis**: consists of more detailed investigation of the core material typically using the same techniques as Stage 3, but with extended counting and/ or higher sampling intervals within key stratigraphic units. The work will be undertaken to a high standard which should permit the publication/ dissemination of the results. The results of the Stage 4 analysis will be used to enhance/ refine the deposit/ ground model. Stage 5 will proceed in the event that further publication of the findings is required.

- **Stage 5 - Publication**. This project format is designed to flow sequentially with each phase leading to the subsequent phase of work or representing the end of the assessment if the findings of any stage show that no further work is necessary.

4.2.1 Stage 1 - Geoarchaeological review of core logs

Stage 1 review will be undertaken on the logs and photographs for the cores. A desk based review will be undertaken to identify core material which has the potential to provide information in the following areas:

- Cores containing sediments that can be related to a pre-marine transgression period at the end of the Pleistocene / beginning of the Holocene;
- Cores that show evidence of a transition from organic-rich clays / peats, associated with dryland edge marsh / fen environments, towards saltmarsh and subsequent full marine inundation;
- Cores that have the potential to provide information about past sea level that can be used to enhance our understanding of when this part of the Irish Sea was flooded and therefore no longer inhabitable to people;
- Cores containing organic material that can be readily dated to establish the age of the deposits;
- Boreholes that sample Pleistocene deposits that are associated with terrestrial / coastal sediment deposition;
- Cores likely to contain ecofacts that can be used to reconstruct the past environment; and
- Material suitable for dating (e.g. Radiocarbon or Luminescence dating). Material potentially suitable for Luminescence dating will be identified during the preliminary Stage 1 geoarchaeological assessment.

Recording will be undertaken by the geotechnical contractor, using Eurocode 7, to describe sediments. Any additions to this will be to British Standard and will be specified where used. Characteristics which are of archaeological interest will be logged. In particular, any evidence of the following will be recorded:

- Fine-grained sediments indicative of fluvial/estuarine conditions;
- Organic materials such as peat, wood or charcoal which can be used to date sediment layers and provide information on past environments;
- Visible palaeoenvironmental and paleoclimatic indicators such as mollusc shells and plant remains;
- Mammal macrofaunal remains which can be used to reconstruct landscape and habitat; and
- Archaeological artefacts which provide direct evidence of a prehistoric human presence in the palaeolandscapes.

The presence of any of the above features or inclusions should be noted within the core log, where observed.

Any voids within the cores should also be noted, along with the depths of the voids. Likewise, areas of loose sediment should be noted, again, along with depths.

All samples should be photographed in good light. Photographs should cover the entirety of the core (although this can be done in separate sections), including any areas of loose material or voids.

Geotechnical logs and photographs will be provided to the RA for geoarchaeological assessment. The RA will work with the geotechnical contractor to ensure core recording is carried out to an acceptable standard to facilitate geoarchaeological assessment, which may include optional visit(s) to the geotechnical contractor's onshore laboratory facility for monitoring.

At the completion of the geotechnical survey(s), COARS will advise the Project which cores may have geoarchaeological potential and should be subject to Stage 2 visual inspection and any subsequent geoarchaeological recording. Sediments and layers of interest will be identified based on knowledge gathered from previous assessments as seen in Table 2.

This procedure is in accordance with the Guidance on Offshore Geotechnical Investigations and Historic Environment Analysis (Gribble and Leather 2011). Stage 2 geoarchaeological recording will require a geoarchaeological description of the core material to be undertaken, following Historic England's Geoarchaeology guidance (Historic England 2015) and the marine geoarchaeology techniques taught on the Historic England-funded Marine Geoarchaeology CPD Training Course (Grant et al. 2017).

The results from Stage 1 will be reported on within the Stage 2 assessment report.

4.2.2 Stage 2 - Geoarchaeological recording

Samples recommended for Stage 2 geoarchaeological recording will be visually inspected and recorded in accordance with the Stage 2 geoarchaeological assessment, and a report with recommendations, including storage requirements (i.e. duration or disposal) for any samples will be produced.

Not all cores would be recorded if, after visual inspection, they are deemed to not have any geoarchaeological potential (e.g. glacially derived). The reasons for excluding any cores from recording after visual inspection will be included within the subsequent report, for clarity.

Geoarchaeological recording can take place at the geotechnical contractor's facilities or alternatively be transported back to the laboratories at the National Oceanography Centre Southampton (NOCS). The latter has the advantage that it will allow the geoarchaeologist easy access to the cores should sampling be required for Stage 3 assessment or any subsequent Stage 4 analysis. It also means that the cores can be placed within temperature controlled storage at NOCS to reduce any deterioration of the core material from processes such as fungal growth or drying out which could ultimately lead to contamination of the samples for techniques such as radiocarbon dating or the loss of biological remains (such as pollen).

Geoarchaeological recording will include, but not limited to:

- Depth range (e.g. 0-25cm);
- Main colour (using a munsell chart);
- Mottles colour/Size abundance;
- Texture by feel;
- Structure;
- Stones – content/type/shape;
- Roots/size/shape/abundance;
- Boundary sharpness; and
- Notes/Horizon name.

Any suitable Luminescence dating samples will be taken. Having identified suitable units, the core should be sectioned to create a 300 mm long semi-cylinder that is centred on a Luminescence dating sample and maintains the original core diameter in so far as possible. The cylinder should then be wrapped in several layers of clingfilm to maintain sample integrity and preserve moisture content; the sample number should be marked on the clingfilm. Three layers of aluminium foil should then be applied and secured with tape; again, the sample number should be added to this. Prior to transport, samples should be stored in a dark location, and not in direct sunlight.

The result of the Stage 2 assessment will be delivered as a stand-alone assessment report. If any samples are recommended for Stage 3 geoarchaeological assessment, these will be stipulated within the report including a proposed methodology for the Stage 3 work.

4.2.3 Stage 3 - Geoarchaeological assessment

Samples recommended for Stage 3 geoarchaeological assessment within the Stage 2 report and recommended for further investigation, will be subject to sub-sampling and assessment by the retained geoarchaeologist. This assessment will follow the methodology set out within the recommendations of the Stage 2 report and agreed by the Project and RCAHMW.

Results and conclusions from this stage will be delivered as a stand-alone assessment report, including any recommendations for conducting Stage 4 geoarchaeological analysis. A proposed methodology for the Stage 4 analysis will be included within this report.

4.2.4 Stage 4 - Geoarchaeological analysis

If the Stage 3 geoarchaeological assessment recommends further investigation of any of the deposits, this would be undertaken during Stage 4 geoarchaeological analysis. This analysis will follow the methodology set out within the recommendations of the Stage 3 report and agreed by the Project and RCAHMW. This stage will result in an account of the successive environments within the coring area, a model of environmental change over time, and an outline of the archaeological implications of the analysis collated into a high-level report.

4.2.5 Stage 5 - Publication

The geoarchaeological results can be integrated with the findings of other relevant projects and submitted for publication where suitable. The appropriate level of publication and dissemination will depend on the results of this assessment, the advice of RCAHMW and any confidentiality clauses. Publications can be submitted to

national and local academic journals, local interest magazines, or online publications and platforms for open access. It should be made clear within the Stage 3 or 4 reports if publication of the results is suitable or not.

4.2.6 Project ground model

Previous archaeological assessment work has determined the presence of several potentially significant features within the development area, with certain deposits (Unit IV, V and VI) from the Project ground model (Table 2) highlighted as having geoarchaeological potential (see also Section 1.2). Following the planned SI, the results will feed into the evolving project ground model.

4.3 Geotechnical Archaeological Assessment Report

Subsequent geotechnical reports, considering all available geotechnical data, will be produced as a stand-alone assessment.

A final assessment report and Project ground model will be produced to a level of detail that will reflect the stage reached during the project. This report will describe:

- The nature of the deposits and the sedimentary sequence with a relative chronology;
- Palaeoenvironmental change of the development area;
- The archaeological potential of the deposits studied;
- Scheme impacts;
- Significance of impact;
- Impact mitigation; and
- It will also add to the current ground model.

4.4 Management of Data

4.4.1 Storage, retention and disposal of samples

All data collected as part of the works will be managed in the following way in line with communication between the laboratory and the geoarchaeologist:

- **Storage**: All geoarchaeological environmental samples should be treated in accordance with The Crown Estate (2021) guidance. This will include all samples being stored in appropriate conditions by the geotechnical contractor/s and archaeological contractor/s pending assessment and analysis work. In line with recommendations in English Heritage (2011: 14), samples should be kept cool with light and air excluded. This also includes any samples that are collected specifically for Luminescence dating. When the cores are stored with the contractor, all remaining liners will be re-sealed using cling wrap and adhesive tape to ensure the samples do not dry out, they will then be stacked and stored horizontally in metal cages or on open-shelved racking while being kept in a cool, dark, temperature-controlled environment.
- **Core and sample retention**: Geoarchaeological samples deemed to have archaeological potential should be retained by the geotechnical contractor(s) and / or archaeological contractor(s) during the construction phase of the project or until the geoarchaeological assessments have reached the last stage, whichever is last. If cores are deemed not to have potential, then they no longer need retention once these recommendations have been agreed with RCAHMW.
- **Disposal**: A timetable will be agreed with both the geotechnical contractor(s) and MA on the length of storage of samples. This should be sufficient to allow all appropriate analysis to be undertaken. The results of the various stages of archaeological assessment will determine the archaeological significance of each of the samples. Only after the results of the assessment and in agreement with the curators will sample material be disposed of as per internal guidelines of the geotechnical contractor(s) and MA.

4.4.2 Digital data management plan

The digital data created by this Project will consist of reports and spatial data. Reports will be created and managed by MA while spatial data will be created and managed by Mona Offshore Wind Limited.

Digital data will be created and managed as set out in *Dig Digital* (CiFA, 2019). The reports will be managed by using a revision system at the start of each report, clearly stating the revision number and any changes that were made since the last revision.

4.4.3 Archiving

A final digital copy of the report will be submitted to the curator, RCAHMW, and to Coflein (Coflein is the online database for the National Monuments Record of Wales (NMRW) – the national collection of information about the historic environment of Wales).

In addition, an OASIS form will be completed and submitted online to be shared on the Archaeological Data Service (ADS). The FAIR Guiding Principles will be used as they represent good digital data management, ensuring that all digital data is findable, accessible, interoperable and reusable (CiFA, 2019).

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